

WHAT IS CLAIMED IS:

1. A computer-implemented method for generating page rankings using a user access log, comprising:
 - 5 extracting implicit links from the user access log;
 - generating an implicit links graph from the extracted implicit links;
 - and
 - computing page rankings using the implicit links graph.
- 10 2. The computer-implemented method of claim 1, further comprising segmenting the user access log into a plurality of different browsing sessions.
- 15 3. The computer-implemented method of claim 2, wherein extracting implicit links further comprising using a two-item sequential pattern mining technique to extract the implicit links from the plurality of different browsing sessions.
- 20 4. The computer-implemented method of claim 1, further comprising defining a generative model for the user access log based on the implicit links graph.
- 25 5. The computer-implemented method of claim 1, wherein the implicit links graph is a weighted direct graph.
6. The computer-implemented method of claim 5, wherein the implicit links graph is described by the equation $G' = (V, E')$, where V is a set of vertices representing all pages in a search space and E' encompasses a set of implicit links between the pages.

7. The computer-implemented method of claim 6, wherein each of the implicit links further includes a conditional probability parameter of a page to be visited given a current page.

5 8. The computer-implemented method of claim 1, wherein extracting implicit links further comprises analyzing observed explicit links in the user access log.

10 9. The computer-implemented method of claim 3, wherein the two-item sequential pattern mining technique further comprises moving a gliding window over each explicit link path in the user access log.

10. The computer-implemented method of claim 9, further comprising generating order pairs of pages using the gliding window.

15 11. The computer-implemented method of claim 1, further comprising updating the implicit links graph by setting all weights in two-item sequential patterns to zero.

20 12. The computer-implemented method of claim 11, further comprising adding a support to each of the weights.

13. A computer-readable medium having computer-executable instructions for performing the computer-implemented method recited in claim 1.

25 14. A process for enhancing initial results obtained from a search engine on a computer using a user access log, comprising:
extracting implicit links of pages from the user access log using a two-item sequential pattern mining technique;
30 generating an implicit links graph from the implicit links;
generating two-item sequential patterns from the implicit links;

updating the implicit links graph using the two-item sequential patterns; and

re-ranking the initial search results using the updated implicit links graph.

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15. The process as set forth in claim 14, further comprising pre-processing the user access log.

16. The process as set forth in claim 15, wherein pre-processing further comprises at least one of: (a) data cleaning; (b) session identification; (c) consecutive repetition elimination.

17. The process as set forth in claim 15, wherein pre-processing further comprises data cleaning of the user access log by filtering out any access entries for embedded objects.

18. The process as set forth in claim 15, wherein pre-processing further comprises performing session identification on the user access log to distinguish each user in the log by their Internet protocol (IP) address.

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19. The process as set forth in claim 15, wherein pre-processing further comprises performing consecutive repetition elimination to handle a situation where multiple users have the same IP address.

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20. The process as set forth in claim 19, further comprising removing IP addresses whose page hits count exceeds a threshold.

21. The process as set forth in claim 15, further comprising segmenting the pre-processed user access log into browsing sessions.

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22. The process as set forth in claim 21, further comprising grouping consecutive entries of the user access log into a browsing session.

23. The process as set forth in claim 21, further comprising generating 5 ordered pairs of pages from the segmented user access log.

24. The process as set forth in claim 23, further comprising filtering the ordered pairs using a minimum support threshold to remove any ordered pairs that are infrequently occurring in the user access log.

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25. The process as set forth in claim 14, wherein re-ranking the initial search results using the updated implicit links graph further comprises using a modified implicit link analysis technique for re-ranking.

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26. The process as set forth in claim 25, wherein the modified implicit link analysis uses a modified re-ranking formula.

27. The process as set forth in claim 26, wherein the modified implicit link analysis uses at least one of: (a) score-based re-ranking technique; (b) 20 order-based re-ranking technique.

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28. One or more computer-readable media having computer-readable instructions thereon which, when executed by one or more processors, cause the one or more processors to implement the process of claim 14.

29. A computer-readable medium having computer-executable instructions for enhancing local searching of web sites and intranets by mining user access logs, comprising:

30 segmenting the user access log into different browsing sessions; generating ordered pairs of pages from the browsing sessions to find implicit links;

constructing an implicit links graph from the implicit links;
generating two-item sequential patterns from the ordered pairs;
updating the implicit links graph using the two-item sequential
patterns; and

5 re-ranking search results obtained from a search engine to
enhance the local searching.

30. The computer-readable medium of claim 29, further comprising pre-
processing the user access log using at least one of: (a) data cleaning; (b)
10 browsing session identification; (c) consecutive repetition elimination.

31. The computer-readable medium of claim 29, further comprising
identifying each individual ones of the browsing sessions.

15 32. The computer-readable medium of claim 31, further comprising
identifying in terms of a user identification and a chronological order of pages.

33. The computer-readable medium of claim 29, further comprising
using a gliding window to move over explicit paths of the browsing sessions to
20 generate the ordered pairs.

34. The computer-readable medium of claim 33, further comprising
defining the gliding window size, wherein the size represents a maximum interval
a user clicks between a source page and a target page.

25 35. The computer-readable medium of claim 29, further comprising
filtering the ordered pairs to remove any ordered pairs that are infrequently
occurring.

30 36. The computer-readable medium of claim 35, further comprising
determining a frequency of each of the ordered pairs.

37. The computer-readable medium of claim 36, further comprising:
defining a minimum support threshold; and
applying the minimum support threshold to the frequency of each of
5 the ordered pairs.

38. The computer-readable medium of claim 37, further comprising
discarding an ordered pair if its frequency is below the minimum support
threshold.

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39. The computer-readable medium of claim 37, further comprising
keeping an ordered pair if its frequency is above the minimum support threshold.

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40. A computer-implemented method contained on computer-readable
media having computer-executable instructions for execution on a computing
device for enhancing initial search results of a search engine performing a local
search of a web sub-space using a user access log, comprising:
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pre-processing the user access log;
segmenting the log into browsing sessions;
generating ordered pairs from the browsing sessions;
filtering the ordered pairs using a minimum support threshold to
remove any infrequently occurring ordered pairs to generate two-item sequential
patterns;
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updating an implicit links graph using the two-item sequential
patterns; and
re-ranking the initial search results using the updated implicit links
graph.

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41. The computer-implemented method as set forth in claim 40, further
comprising discarding any ordered pairs having a frequency below the minimum
support threshold.

42. The computer-implemented method as set forth in claim 40, further comprising keeping any ordered pairs having a frequency above the minimum support threshold.

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43. The computer-implemented method as set forth in claim 40, further comprising defining an adjacency matrix to describe the updated implicit links graph.

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44. The computer-implemented method as set forth in claim 43, further comprising computing a page rank using the adjacency matrix.

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45. The computer-implemented method as set forth in claim 43, further comprising defining a modified re-ranking formula in terms of the adjacency matrix.

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46. The computer-implemented method as set forth in claim 45, further comprising modifying the re-ranking formula using a random walk technique.

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47. The computer-implemented method as set forth in claim 40, further comprising discarding any ordered pairs having a frequency below the minimum support threshold.

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48. The computer-implemented method as set forth in claim 47, wherein the random walk technique further comprises a probability parameter.

49. The computer-implemented method as set forth in claim 40, wherein re-ranking further comprises using an order-based re-ranking technique.

50. The computer-implemented method as set forth in claim 49, wherein the order-based re-ranking technique further comprises using a linear combination of page positions contained on two lists.

5 51. The computer-implemented method as set forth in claim 50, wherein one of the two lists is sorted by similarity scores.

52. The computer-implemented method as set forth in claim 50, wherein one of the lists is sorted by PageRank values.

10 53. The computer-implemented method as set forth in claim 40, wherein re-ranking further comprises using a score-based re-ranking technique.

15 54. The computer-implemented method as set forth in claim 53, wherein the score-based re-ranking technique further comprises using a linear combination of a content-based similarity score and a PageRank value of all pages.

20 55. An implicit links search enhancement system for enhancing initial search results obtained from a search engine by mining a user access log, comprising:

an ordered pairs generator that generates ordered pairs of implicit links from the user access log;

25 an update module that updates an implicit links graph using the ordered pairs; and

a re-ranking module that re-ranks the initial search results based on a modified link analysis technique.

30 56. The implicit links search enhancement system as set forth in claim 55, further comprising a user access log pre-processing module for pre-processing the user access log.

57. The implicit links search enhancement system as set forth in claim
56, wherein the pre-processing module performs at least one of: (a) data
cleaning; (b) identification of browsing sessions within the user access log; (c)
5 consecutive repetition elimination.

58. The implicit links search enhancement system as set forth in claim
55, further comprising a user access log segmentation module that segments
data in the user access log into individual browsing sessions.

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59. The implicit links search enhancement system as set forth in claim
55, further comprising a filter module that removes any infrequently occurring
ordered pairs.

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60. The implicit links search enhancement system as set forth in claim
55, wherein the a modified link analysis technique includes a modified re-ranking
formula and at least one re-ranking technique.

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61. The implicit links search enhancement system as set forth in claim
60, wherein the modified re-ranking formula is modified by using a random walk
technique and a probability parameter.

62. The implicit links search enhancement system as set forth in claim
60, further comprising an order-based re-ranking technique.

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63. The implicit links search enhancement system as set forth in claim
60, further comprising a score-based re-ranking technique.